Pandora Changes Since MCC10

Steven Green on behalf of the Pandora Team
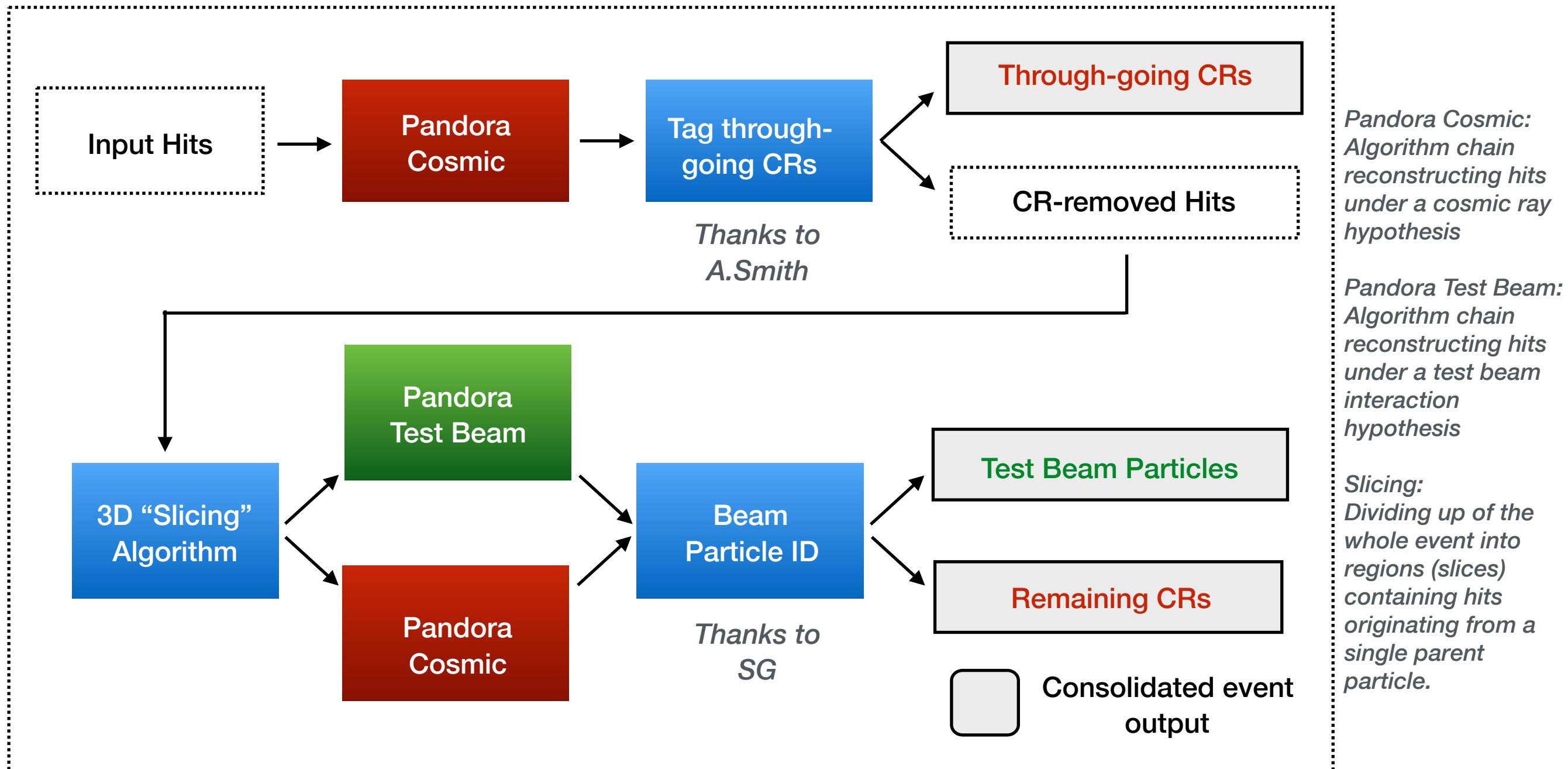
18th July 2018

We've created a slack channel for all questions related to Pandora. Please join if you'd like to ask us anything:
https://pandorapfa.slack.com

○ **Brief reminder of the Pandora reconstruction for ProtoDUNE:**

Pandora Cosmic:
Algorithm chain reconstructing hits under a cosmic ray hypothesis

Pandora Test Beam:
*Algorithm chain reconstructing hits under a test beam interaction hypothesis*

Slicing:
Dividing up of the whole event into regions (slices) containing hits originating from a single parent particle.

Thanks to J.Marshall

○ Now focus on the areas that have changes since the MCC10 production:

Pandora Cosmic: Algorithm chain reconstructing hits under a cosmic ray hypothesis

Pandora Test Beam: Algorithm chain reconstructing hits under a test beam interaction hypothesis

Slicing: Dividing up of the whole event into regions (slices) containing hits originating from a single parent particle.
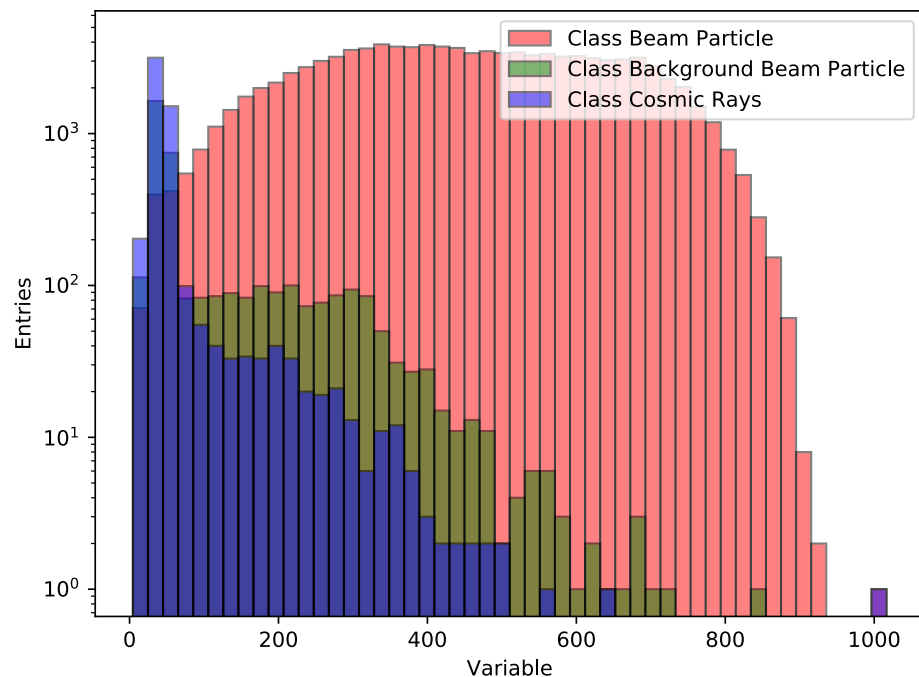
Thanks to J.Marshall

| Pandora Neutrino | → | Beam Particle ID | → | Test Beam Particles |
| Pandora Cosmic | → | | → | Remaining CRs |
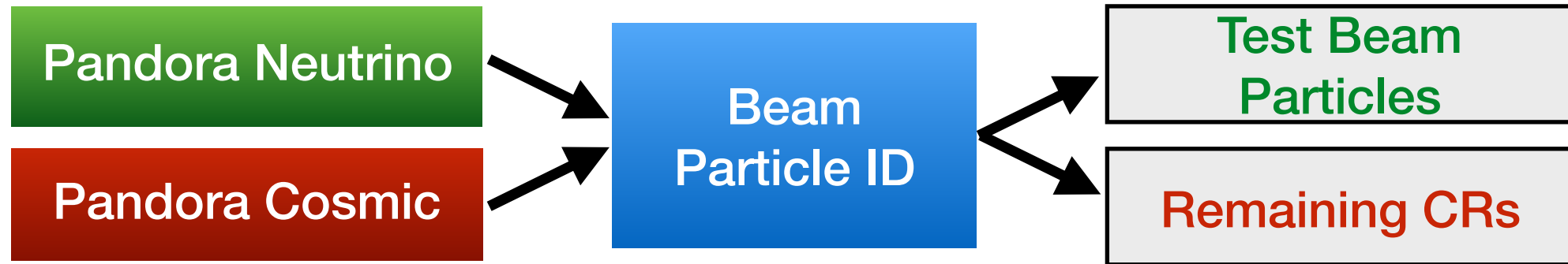
○ The two slice reconstruction outcomes are then analysed to determine the optimal reconstruction in the beam particle ID step.

  ○ MCC10: ID found via a simple cut based approach.
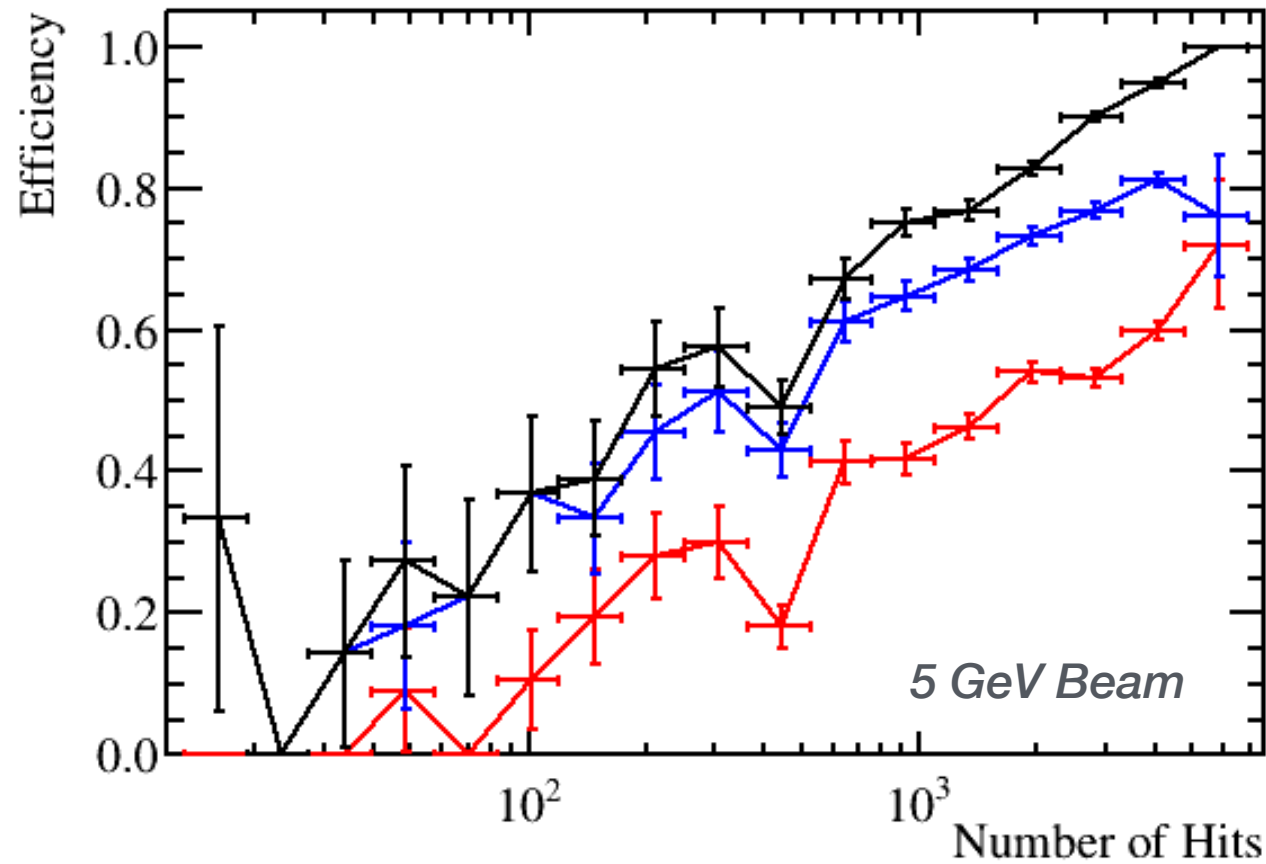
  ○ Now: ID found via Boosted Decision Tree.

BDT Beam Particle ID Variables

  ○ The distance of the closest 3D LArTPC hit to the beam spot. (0)

  ○ The direction and angle of a spatial fit to the reconstructed 3D hits with respect to the beam line. (1-2)

  ○ The eigenvalues of the covariance matrix of the spatial position of the 3D LArTPC hits. (3-5)

  ○ The vertical distance of the reconstructed 3D LArTPC hit closest to the top of the detector. (6)

  ○ The number of reconstructed particles. (7)

5 GeV Beam

Beam Momentum [GeV]	MCC10 Beam Particle ID	BDT Beam Particle ID
1	58.1±1.3	77.4±1.1
3	57.6±2.3	77.6±1.9
5	50.8±0.6	72.3±0.6
7	52.4±0.5	70.8±0.5

Cheated Beam Particle ID
Standard Reconstruction
BDT Beam Particle ID

o This metric folds in effects from cosmic-ray pattern recognition, cosmic-ray tagging, slice creation, both the cosmic-ray and neutrino slice reconstructions and test beam particle identification. *(Reconstructed particles have to be correctly tagged to count towards the efficiency!)*

o The BDT method is far more effective than the cut based approach.

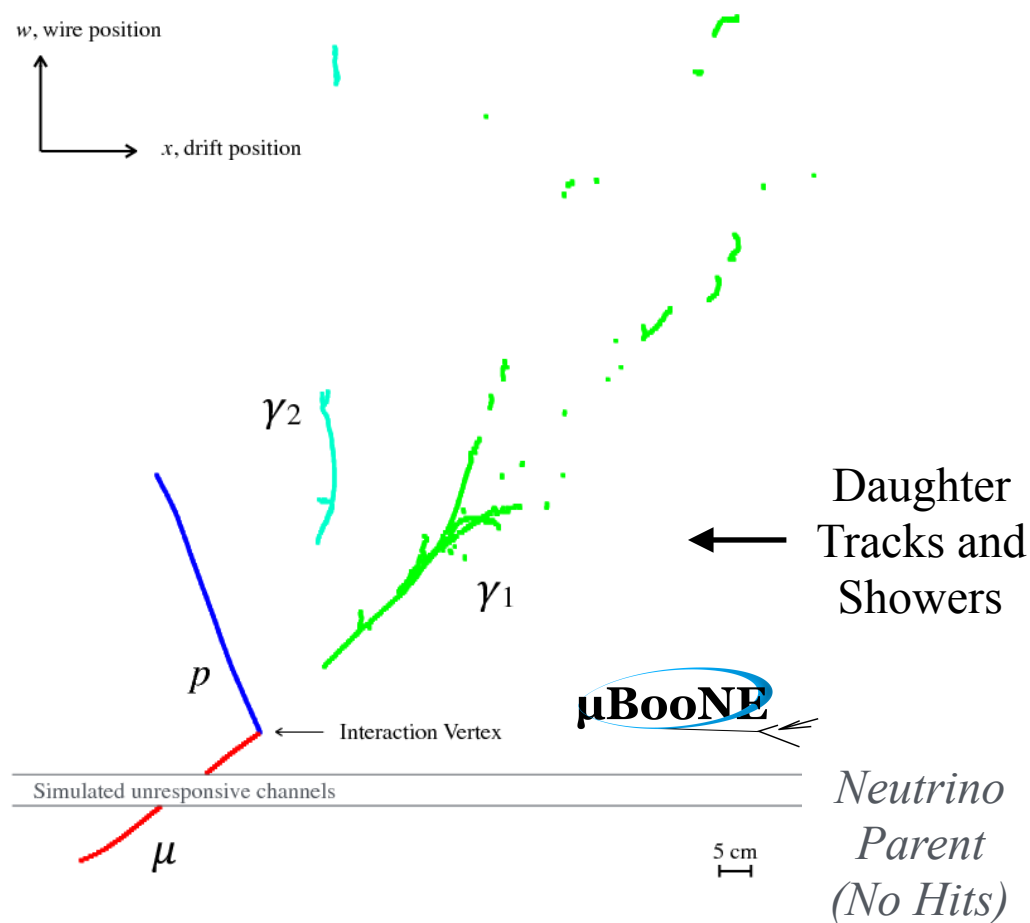o Significant improvement in integrated efficiency across momentum range considered.

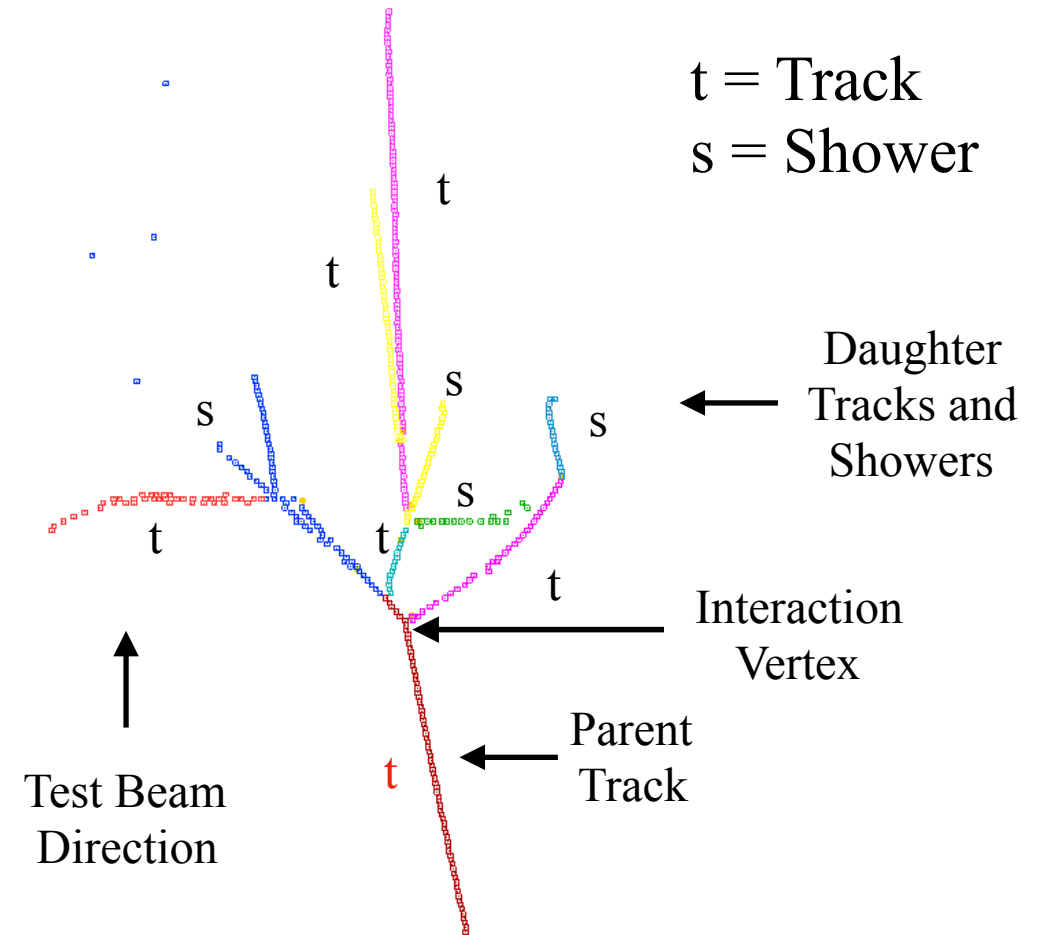o Almost as good as using MC info!

○ **The Pandora output have been restructures to be more intuitive for the test beam use case.**

   ○ MCC10: Test beam particles labelled as neutrinos (PDG code 12/14).

   ○ Now: Test beam particles labelled appropriately (PDG code 211/11 for tracks/ showers) and parent PFParticle associated to incoming test beam particle.

Neutrino Interaction

Pandora MicroBooNE Paper:
Eur. Phys. J. C78, 1, 82 (2018), arXiv: 1708.03135

Test Beam Interaction

t = Track
s = Shower

*Real reconstruction output for a 5 GeV π⁺ interaction in ProtoDUNE-SP*

○ The cuts used to determine whether a cluster is track-like or shower-like (a shower spine) have been updated.

   ○ MCC10: Cuts optimised for MicroBooNE energies.

   ○ Now: More appropriate cuts used for ProtoDUNE.

MCC10 Settings
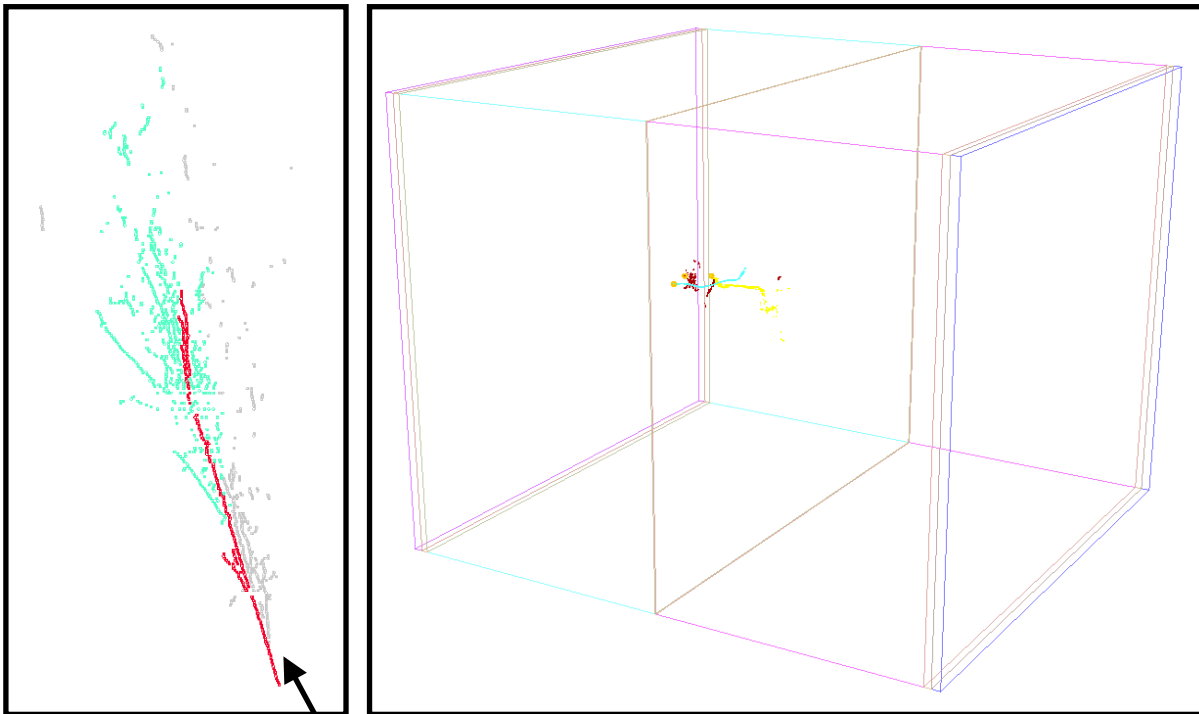
New Settings

The red cluster has been identified as a track rather than a shower spine, which distorts the shower reconstruction.
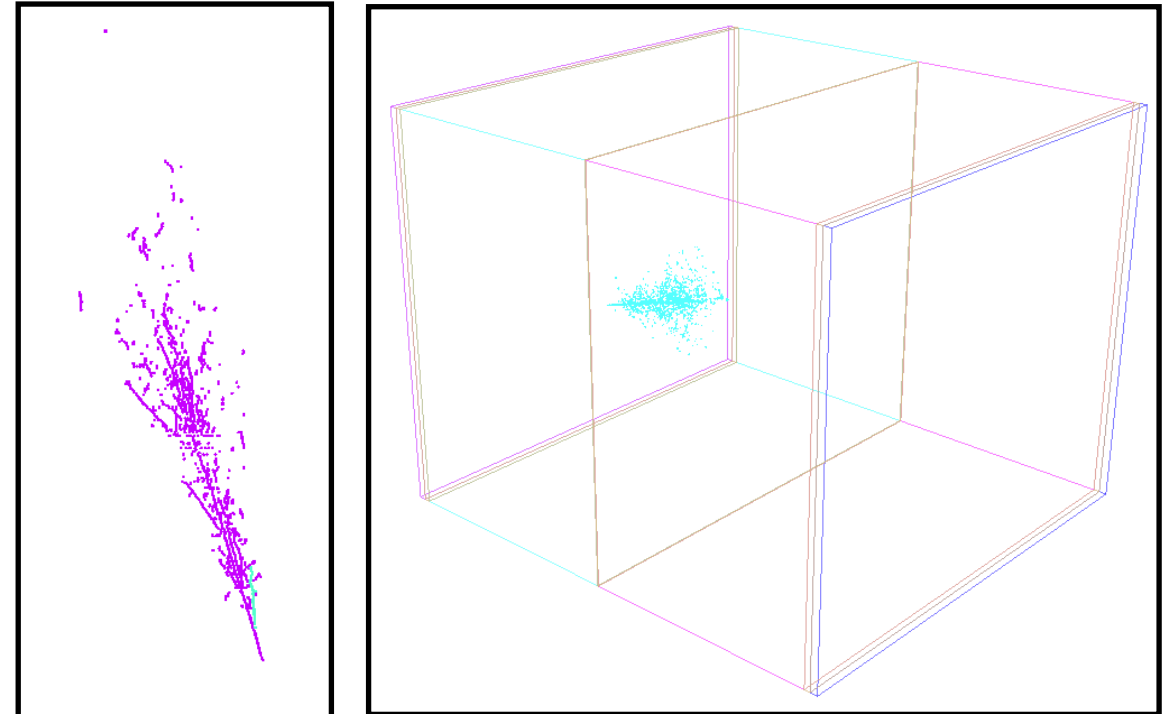
Using the new settings the cluster is identified as a shower spine leading to a better reconstruction.

- A PFParticleMetadata object has been created to save variables of interest to downstream users. The object is a map of string to float.

- The variables of interest we persist at the moment are:

  - "IsTestBeam" - Whether the reconstructed particle been identified as test beam particle.

  - "BeamScore" - Score from BDT.

- Longer term this can be extended to include other variables of interest too (e.g. track shower score is saved for MicroBooNE where an SVM is used).

- MCC10: No PFParticleMetadata object.

- Now: PFParticleMetadata objects exist and BDT score persisted.

```
| pandora........ | std::vector<larpandoraobj::PFParticleMetadata> ………………………………|
| pandora........ | art::Assns<recob::PFParticle,larpandoraobj::PFParticleMetadata,void> ….|
```

○ There have been a number of significant improvements to the Pandora ProtoDUNE reconstruction since the MCC10 production.

○ There's lots of work still to do. Watch this space for details!

Pandora Team

Pandora is an open project and new contributors would be extremely welcome. We'd love to hear from you and we will always try to answer your questions!

Contact details:

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For general enquiries please contact the team via
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Lancaster University

Back Up

Beam Particle ID

Standard Reco — Cheated SliceID

5 GeV Beam

Efficiency vs Number of Hits
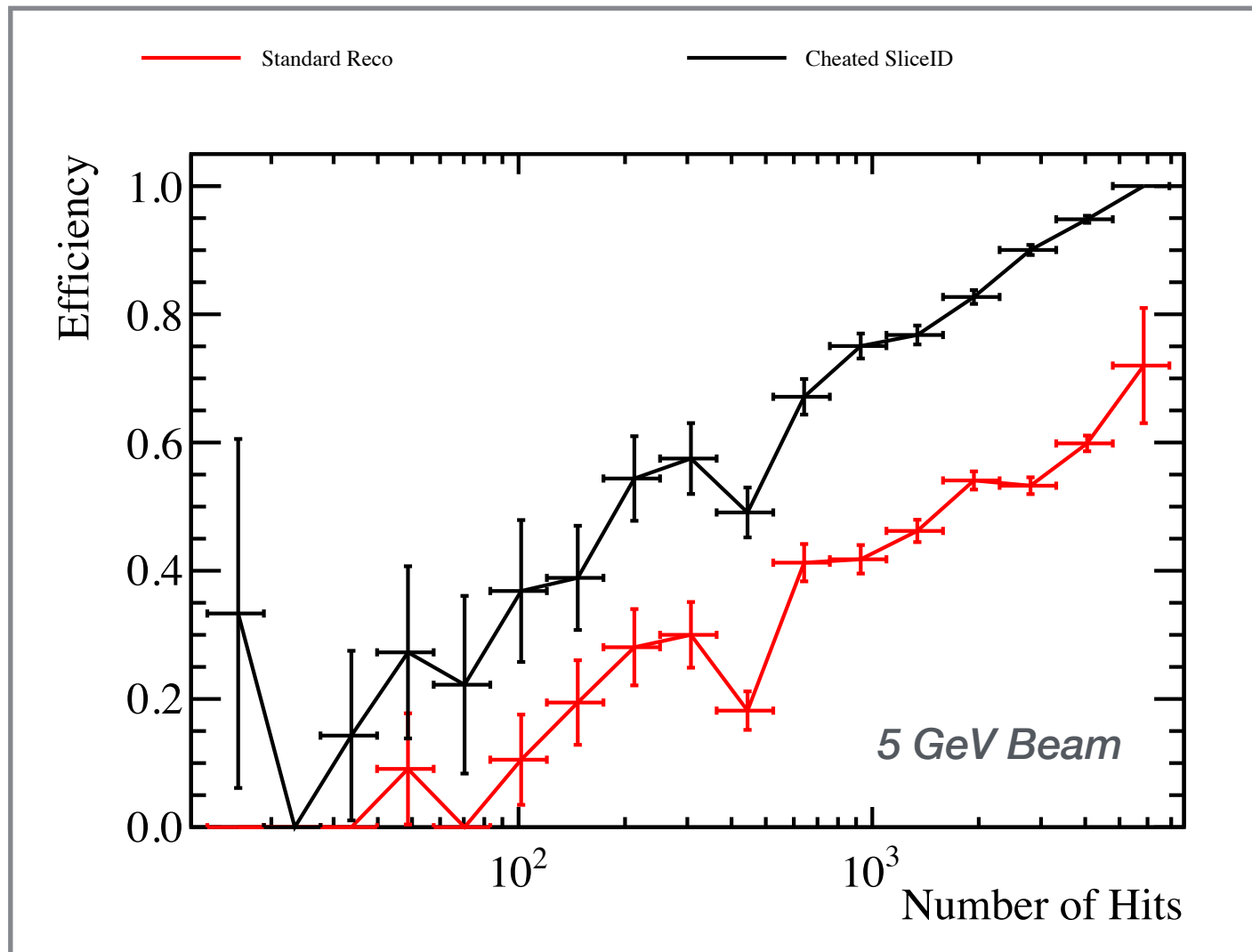
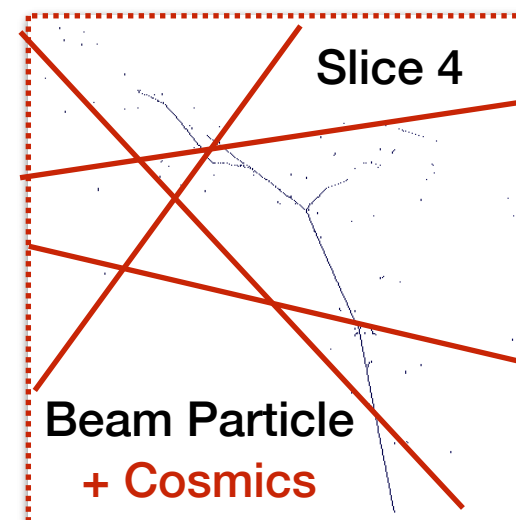## Cheated Beam Particle ID

Standard reconstruction

❓**Why does cheating the beam particle ID not give 100% efficiency?**

➜ **Slices contaminated with cosmic-rays**

○ **Big gains to be made in efficiency if we can improve the beam particle ID.**
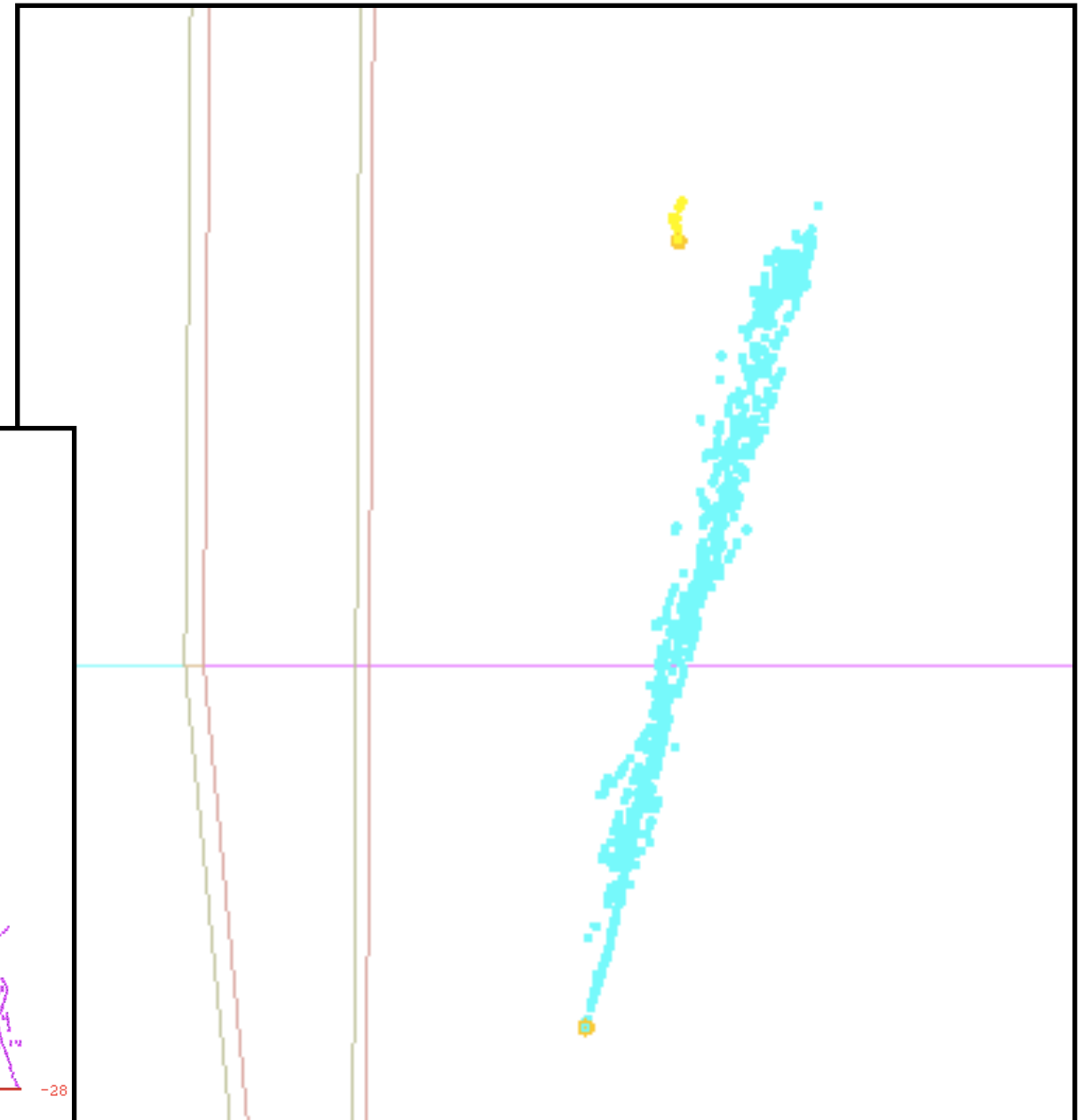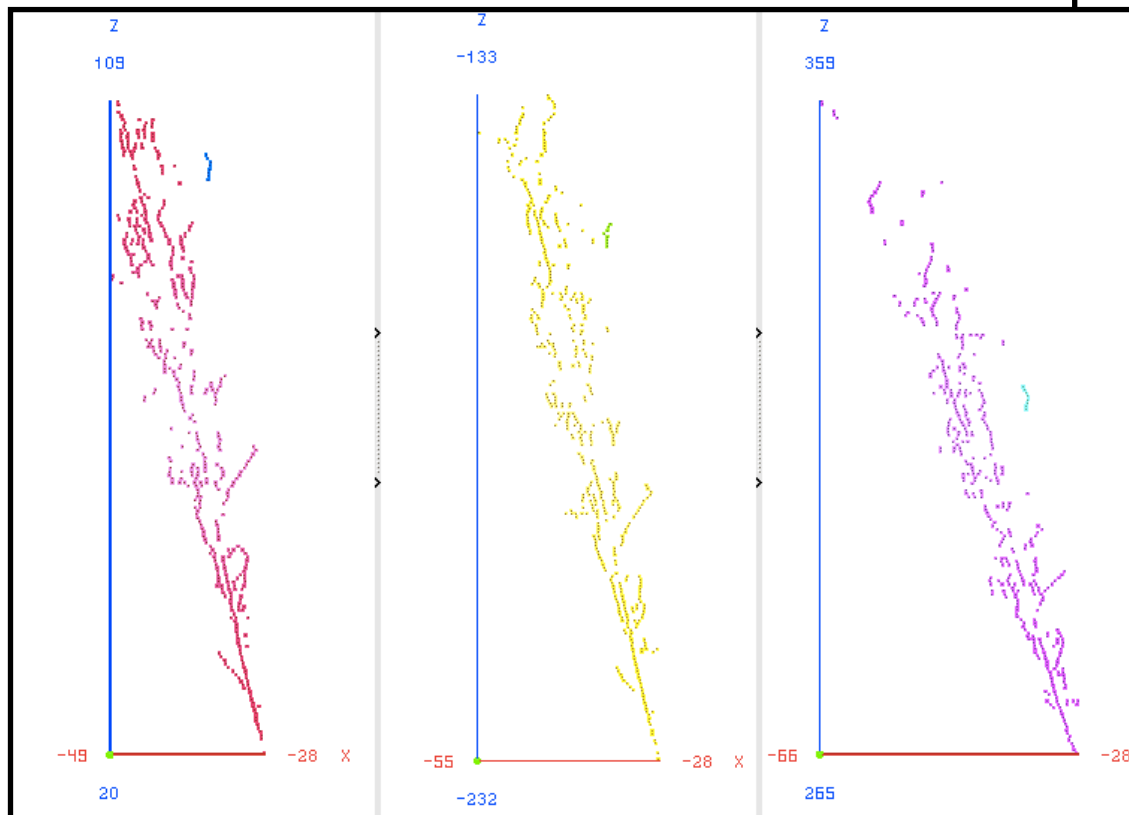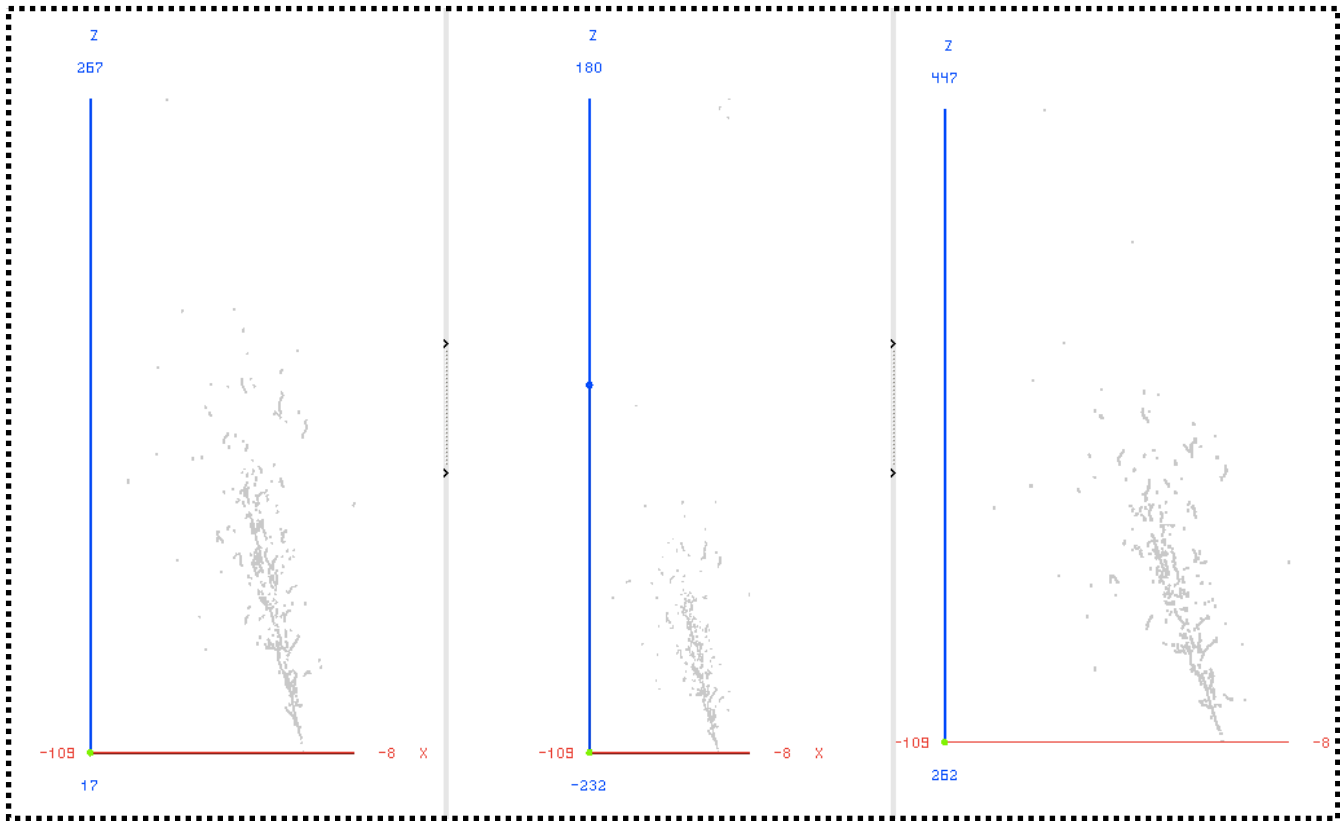

Slice 4
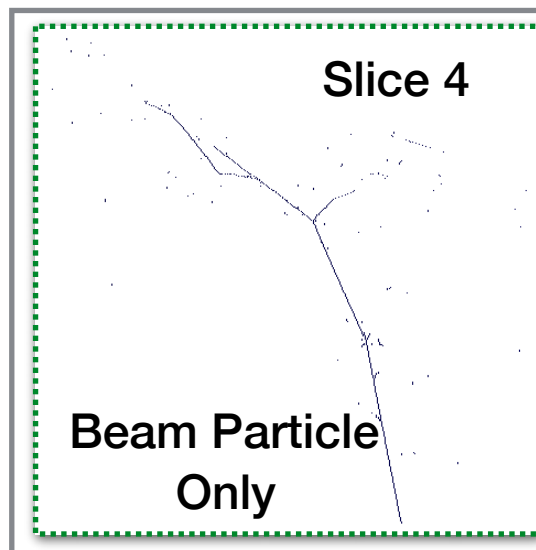
Beam Particle Only

➜*Cheat ID would say beam particle*

Slice 4

Beam Particle + Cosmics

➜*If enough cosmic rays in slice cheat ID would say cosmic ray*

Pandora Neutrino On Test Beam

○ Positron test beam particle

○ **Positron test beam particle**

○ Pion test beam particle

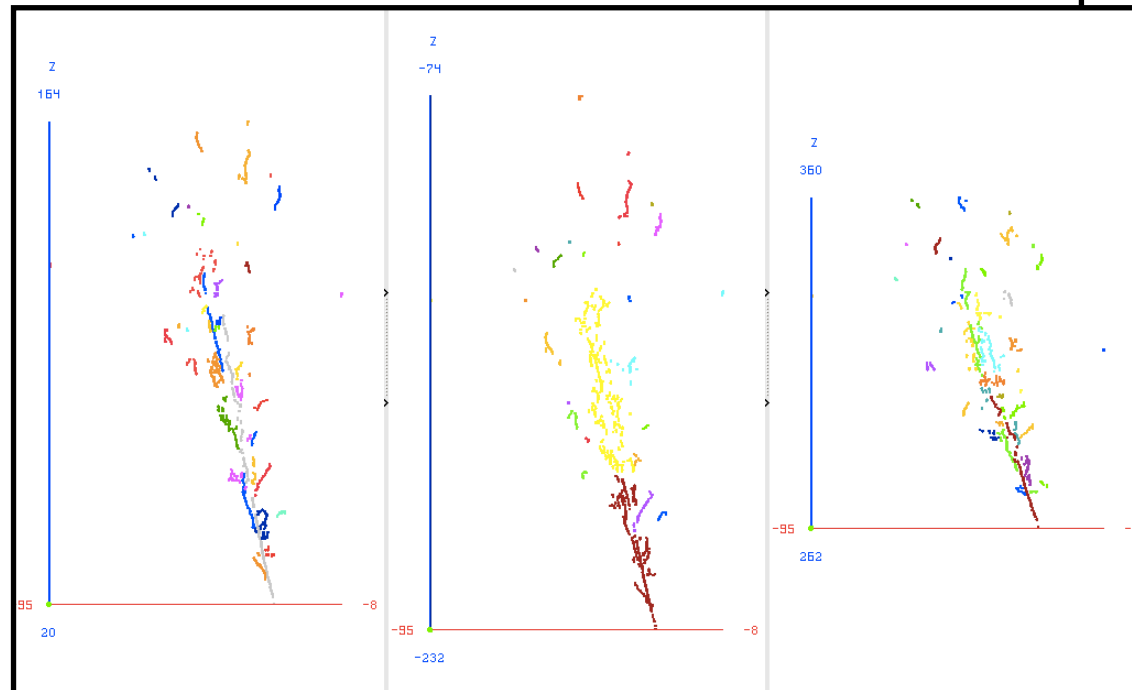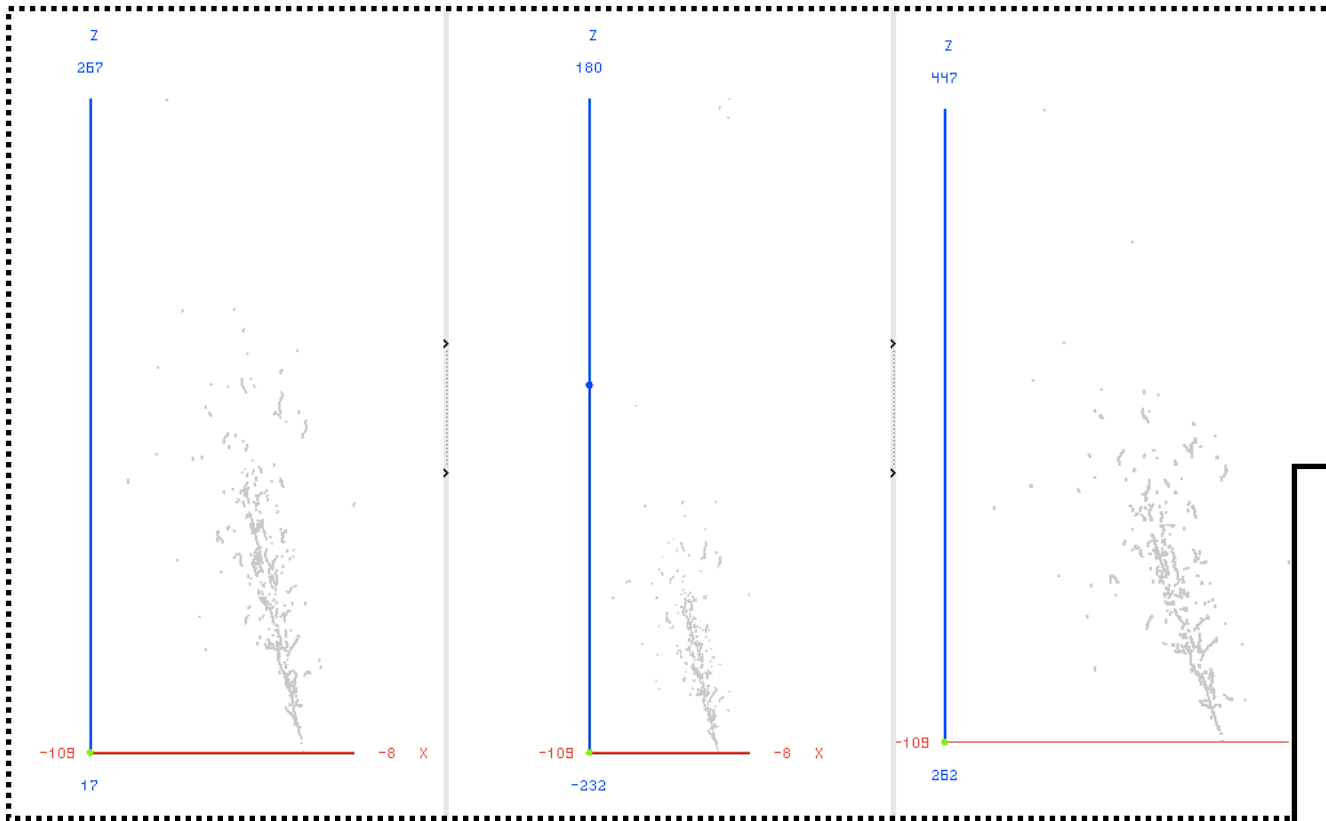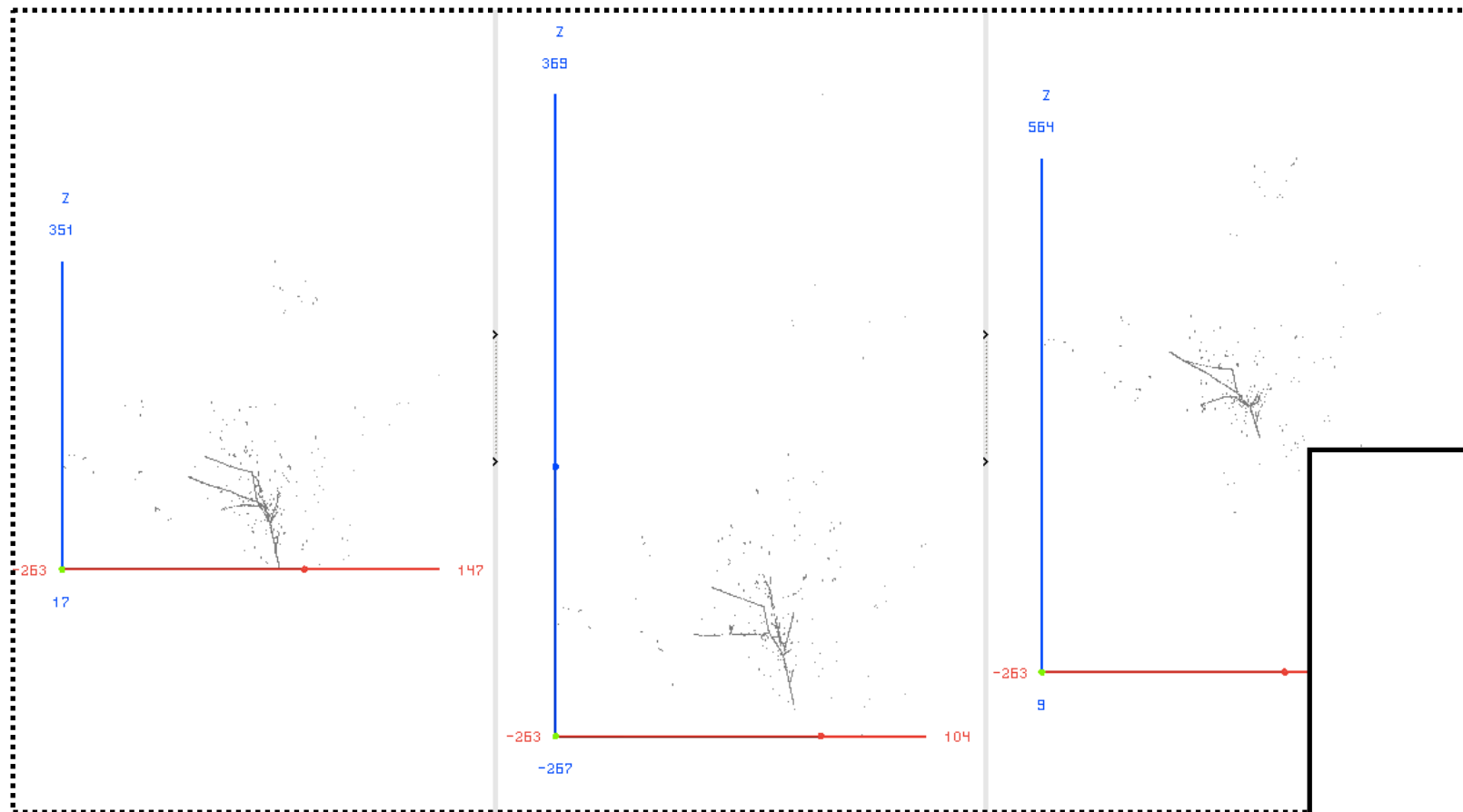# Pandora Cosmics On Test Beam
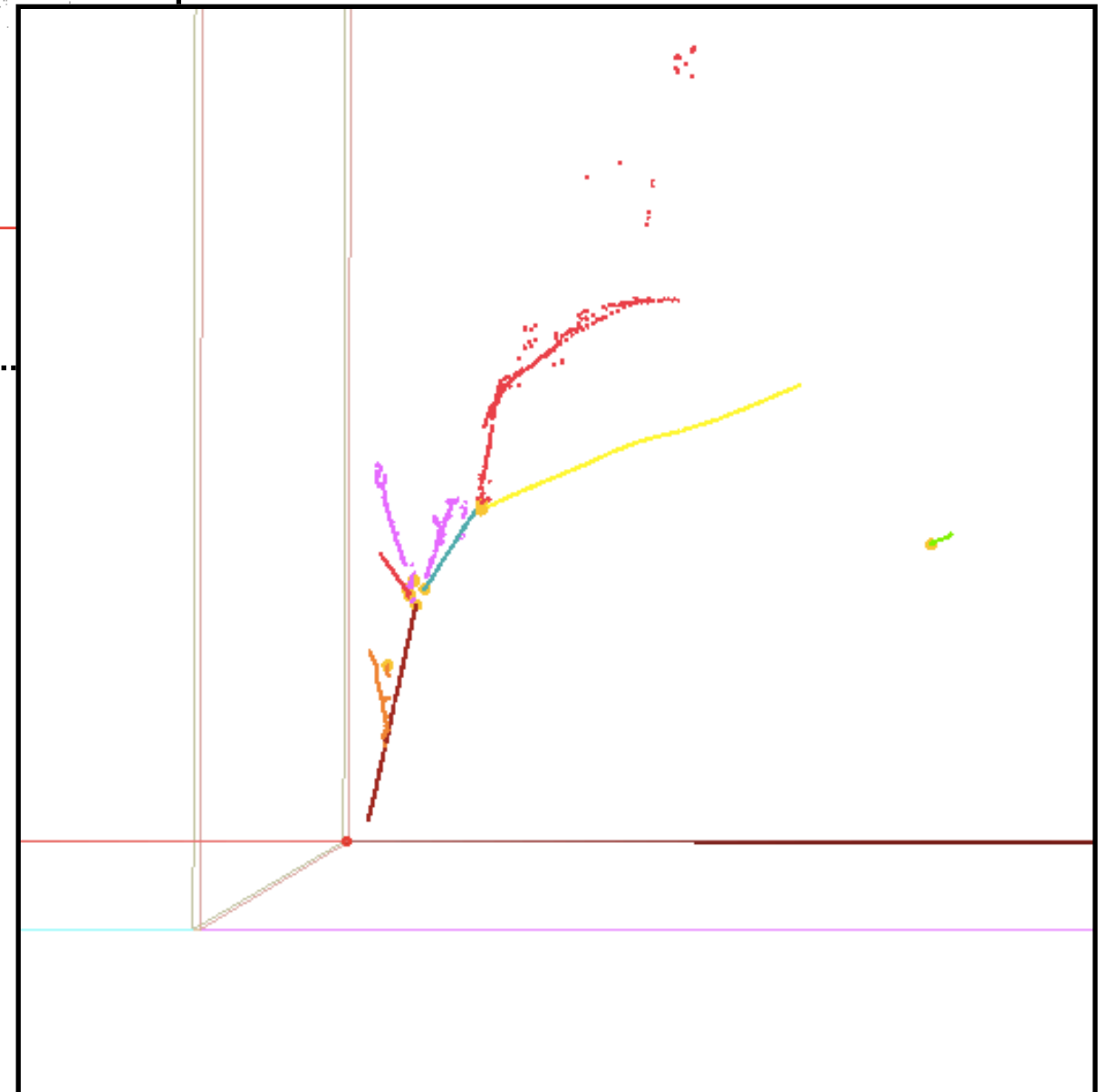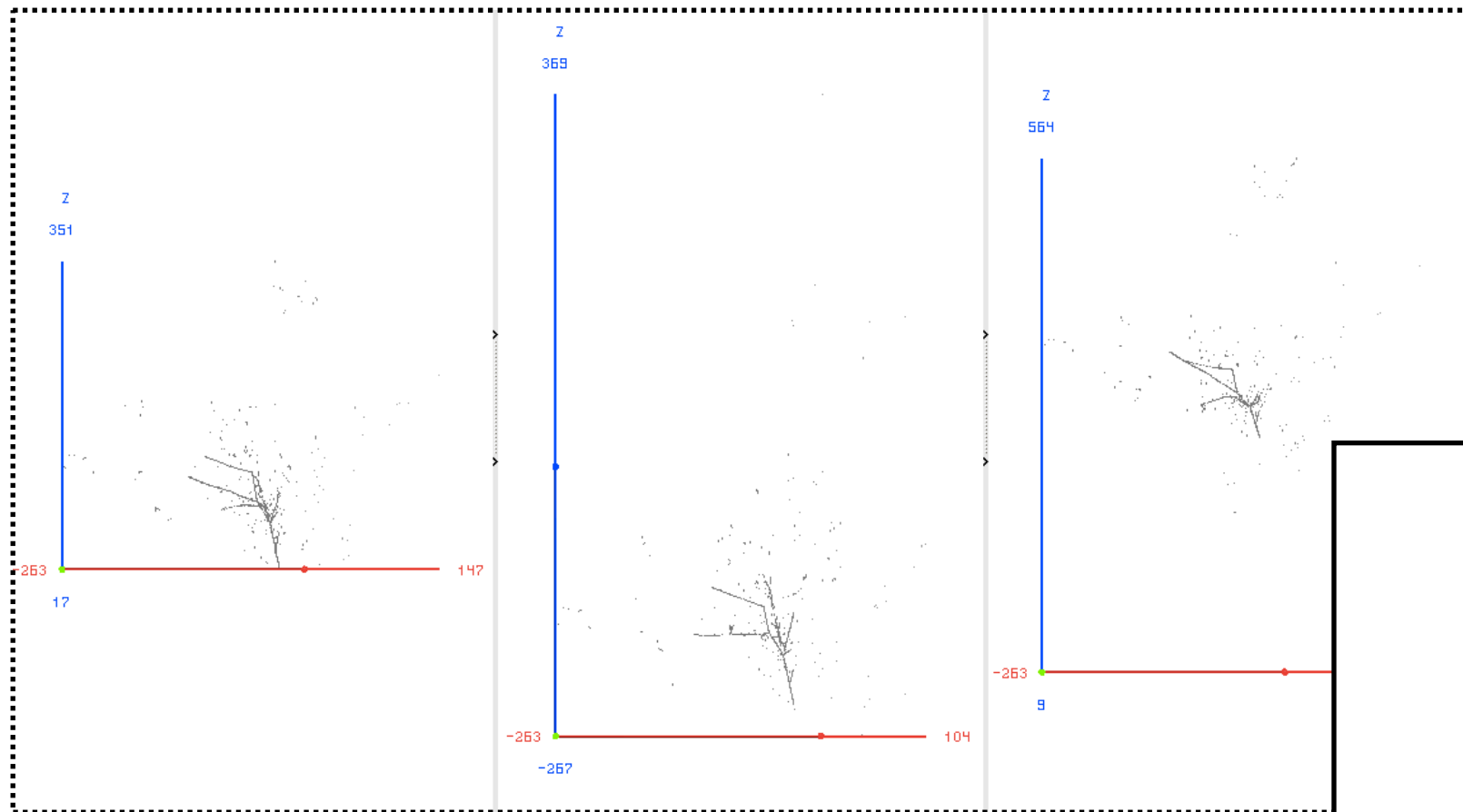
○ **Pion test beam particle**

○ **Track driven through test beam interaction because the Pandora Cosmic algorithm chain is trying to reconstruct cosmic rays.**